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Controls on formation and distribution of heavy minerals along southern tip of India

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ABSTRACT
An attempt has been made to study the southern most tip of India extending on either limbs to a length of 100 kms for varied compositional suite of heavy minerals. A total of 25 samples have been collected to study the control and distributional pattern. The abundant heavies are ilmenite, monazite, garnet, zircon, rutile, tourmaline, limonite, Kyanite, sphene and hornblende. The high concentrations of monazite and ilmenite are more in Kovalam area (min. 12.3% and max. 44.1%) and decreases toward Kanniyakumari (Cape-Camorin). The black sand concentration increase with smaller amounts of garnet giving red hue to the sediment. The transformation of black sand to red is not rapid but gradual with a transitional stage of almost equal proportions of black (50%) and red (50%) sands. This may be due to the disintegration and decomposition of host rock made up of relatively resistant garnet minerals in the interland / floor of the ocean. The relatively resistant heavy minerals might have been detached from the source rock and brought on to the shore forming patches and pockets by winnowing and turbulent actions of waves. In some samples, black hue may be due to the predominance of titanium minerals but not magnetite, which is in meagre amounts. In the study area each species is characterised by the predominance of one constituent which is also emphasised by colour variation. Further, climatic changes play a pivotal role in the formation and distribution of heavy mineral suits, indirectly reflecting the impact of climate in the sedimentary environment. The economically viable heavy mineral deposits along the study area are governed by the presence of host rock in the close proximity, existing drainage pattern, topography, climate and coastal processes. The present study showed that heavy minerals associated with sediments indicate that they are derived from a metamorphic terrain dominated by Precambrian gneiss, schist and ferruginous quartzite of Indian peninsular shield.

INTRODUCTION

The study area selected for the purpose of detailed investigation on the controls and distributional pattern of heavy minerals forms the southern most part of the Indian Peninsula. The coastal sediments deposited along the south coast line belong to the recent and slightly differ texturally and mineralogically (Jayaraju and Reddy, 1995). Studies on heavy minerals along the beaches of Indian coasts have been reported (Narayana et al. 1991; Sreenivasa Rao, Satyanarayana & Swamy 1995; Gajapathi Rao 2002). Most of the previous studies attempted to explain the origin of heavy mineral concentrations. The present study attempts to identify the controls which are governing both the formation and distributional patterns of the heavies in terms of space. The study area lies between Long. 77^0 10' - 78^0 10' E and Lat 8^0 05' - 8^0 25' N covering a shore length of about 100 km which is generally termed as Tri-sea confluence (The Arabian sea, the Indian Ocean and the Bay of Bengal).

MATERIALS AND METHODS

A total of 25 sediment samples were collected by pushing down a PVC tube (60 mm diam), from the area (Fig.1). After removing salts and organic matter, heavy minerals were separated using bromoform (Sp. gr. 2.89). After separation and drying, it was found that maximum crop of heavy minerals appeared through a fraction 60-120 mesh. About 200 to 500 grains per slide were counted per sample and the number counts for each minerals were obtained which were converted into weight percentages by following standard method (Young 1966).

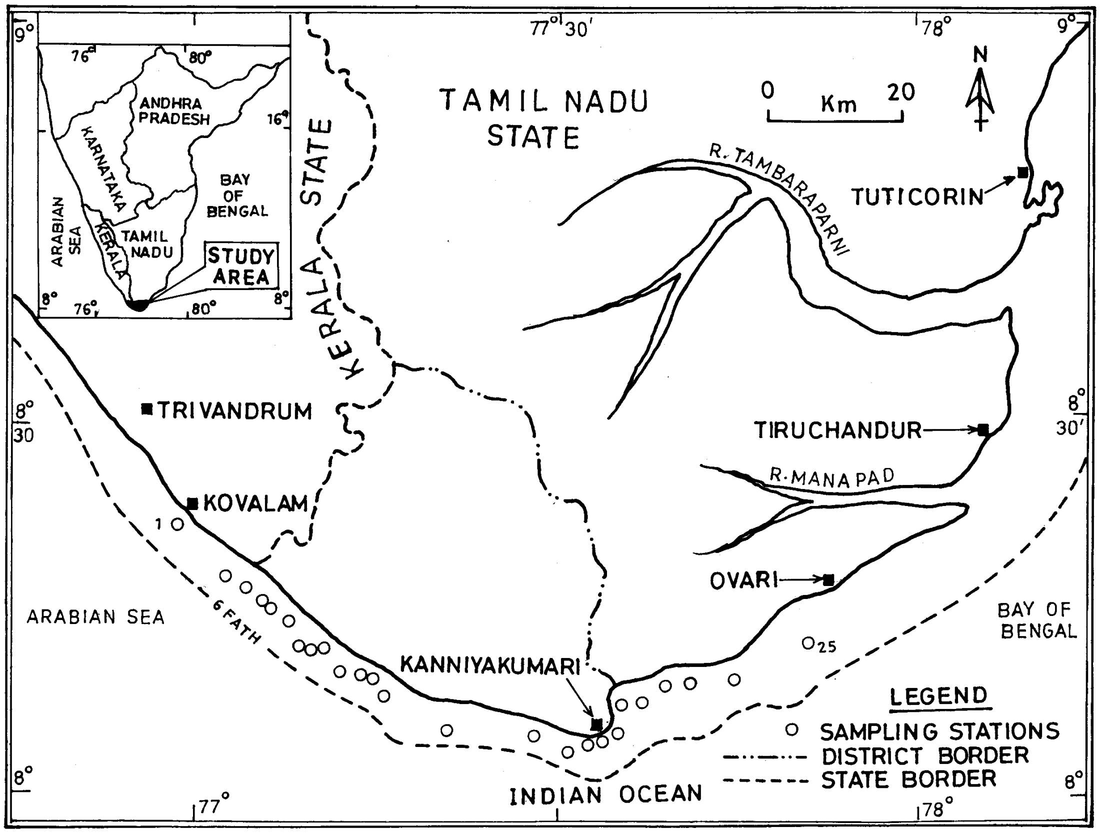

Figure 1. Location map of the study area

RESULTS AND DISCUSSION

The distributional patterns of various heavies of the study area are presented in Table -1. It is very interesting to observe the colouration in the study area. The admirable colour of the sediment is the most obvious and readily observed characteristic feature of an aggregate of its own. However, the exact description of the colour, on an objective basis, is usually possible only by the use of colour charts or a colour dictionary. Krynine (1948) stated four factors that control the colour of the sediment viz.,

1. The total mass of the colour of the component mineral grains of their own aggregate
2. The colour of fine grained matrix or of the content
3. The colour of any thick enamel coating on the grains
4. The degree of fineness of the sedimentary grains

Of these, the 1st and 4th factors control the colour of the heavies in the present study area. The heavies are not always black. At some places viz., Kanniyakumari, some patches are red due to exclusive occurrence of garnet. In this area, the transition from black to red hue is not abrupt but gradual with progressive increase in the proportion of garnet until the sand is almost made up of garnet. This may be due to the disintegration and decomposition of host rock which contains the relatively resistant garnet minerals on the floor of the ocean. The relatively resistant heavy minerals might have been detached from the source rock and brought on to shore/ coast line forming as patches and pockets by winnowing and turbulent actions of waves (Jayaraju 1993). In some samples the black hue is due to the predominance of the titanium minerals (Ilmenite, Rutile), and not due to magnetite. Thus, each species is characterised by the predominance of one constituent which is also emphasised by colour variation. Heavy minerals that are economically viable in the study area include ilmenite, monazite, zircon, rutile, garnet etc. Monazite and Ilmenite are dominating (ave. 44.1%) where as others range from 0.95% to 13.35% (Table 1). Ilmenite and monazite are flooded in both larger (120-230 mesh) and finer fractions (<60 mesh) of heavy mineral crop with irregular, sub angular to sub rounded and poorly sorted grains, which may due to the presence of coarser sand (Jayappa & Subramanya

Table 1. Average concentration of heavy minerals (grain %)

Heavy Mineral	Fraction (60-120 mesh)	Fraction (120-230 mesh)	Average %
Ilmenitie & Monazite	42.90	45.2	44.1
Garnet	20.20	26.51	13.35
Rutile	8.40	2.48	5.44
Zircon	3.20	1.52	2.36
Horn blende	2.30	1.10	1.70
Kyanite	1.50	1.12	1.13
Tourmaline	1.45	0.92	1.18
Limonite	1.12	0.78	0.95

1991). High concentrations are confined around Kovalam and Kanniyakumari beaches. Zircon is more abundant (ave 2.36%) in medium fractions (60-120 mesh). It is generally subhedral with rounded terminations, occasionally with iron oxide coated rims. This is considered to be the most common accessary mineral in the granitic terrain present at almost all stations. Rutile (ave. 5.44%) occurs as reddish brown rods with subrounded grains with presentation of some crystal faces with sub angular to irregular outlines (Tiwari & Yadav 1993). Rutile is present in small amounts in certain amphibolites (Jagadeeswara Rao 1965). Garnet varies from 20.2% in coarser fraction to 6.57% in finer fraction (ave 13.35%). The grains are typically pink in colour (almandine) with high relief and are subangular to subrounded and well to moderately sorted. Garnet is luxuriant crop in Kanniyakumari tri-sea confluence area (ave. 13.35%). Small patches are also not common on either side of the coast. Hornblende and hypersthene are also present in minor quantities. The thick grains are almost opaque, and are distinguished from opaques by a greenish tinge. They are mostly derived from charnockites (Naidu 1974).

Heinrich (1958) outlined the pre-requisites for the concentrations of heavy minerals. They include :

1. A large outcrop area of suitable host rock which contains heavy minerals
2. Disintegration and decomposition of the host rock to liberate these relatively less resistant accessories
3. Residual concentration of heavies through substraction of much of the light fraction of chemically susceptible species by weathering and erosion
4. Relatively rapid movement of this some what concentrated mantle to streams
5. Existing topography and climatic conditions including coastal processes.

The heavy minerals in the study area may be derived originally from the crystalline rock composed of granites and charnockites. It is opined that selective removal of the white sand occurs during accelerated retrogression of the beach at the time of high waves which are responsible for the accumulation of the heavy sands of considerable dimensions (Mahadevan & Sri Ramadas 1954).

The economically viable heavy mineral deposits are governed by the presence of host rock in the close proximity, existing drainage pattern, topography, climate and coastal processes (Gajapathi Rao, 2002). The present study shows that heavy minerals associated with sediments indicate that they are derived from a metamorphic terrain dominated by Precambrian gneiss, schist and ferruginous quartzite of Indian peninsular shield.

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